

# REPORT DOCUMENTATION PAGE

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MEMORANDUM FOR PRR (Contractor/In-House Publication)

FROM: PROI (TI) (STINFO)

20 May 1999

SUBJECT: Authorization for Release of Technical Information, Control Number: AFRL-PR-ED-TP-FY99-0106  
Jay Levine, "Plume Phenomenology Program"

**International presentation**

~~(Foreign Release)~~ Dist A

# PLUME PHENOMENOLOGY PROGRAM

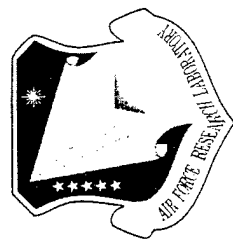


## ONERA

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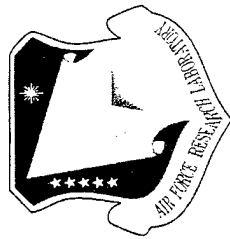
4 June 1999

# Plume-Vehicle Interactions



Jet Interaction Effects -  
Body Heating, Aerodynamic Forces

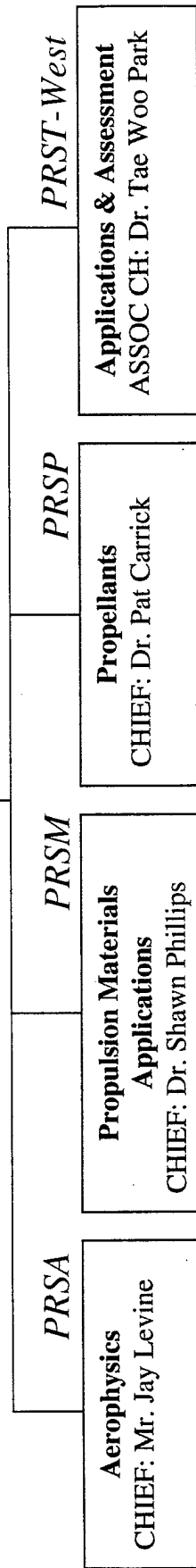




# AFRL Propulsion Directorate

## Propulsion Sciences and Advanced Concepts Division

CHIEF: Mr. Mike Huggins  
Deputy: Maj Mike MacLachlan  
Tech Advisor: Dr. Phil Kessel  
Secretary: Ms. Betty Sumrow



- Rocket plume phenomenology
- Combustion processes and devices
- Spray combustion
- Energetic-material decomposition
- Plasma discharges
- Computational fluid dynamics
- Supercritical fluid mechanics
- Rarefied gas dynamics
- Non-equilibrium flows

- Advanced polymeric components
- Hybrid polymers
- Advanced component fabrication techniques
- Carbon-carbon components
- High temperature coatings
- Nanocrystalline materials
- Functionally graded components
- Solid-propellant fracture mechanics
- Microtube technology
- Ceramic processing

- High energy-density matter
- Liquid rocket propellants and additives
- Solid and hybrid rocket motors and propellants
- Cryogenic propellants
- Energetic molecule synthesis and characterization
- Computational chemistry
- Analytic chemistry
- Environmental propulsion technology
- Propellant hazard analysis
- Missile safety
- Advanced propulsion concepts

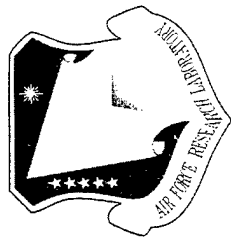
- System-level performance analysis of aerospace vehicles
- Flight trajectory simulations
- Liquid rocket power balance analysis
- Vehicle flight performance prediction
- Propellant requirement estimation
- Technical risk assessment
- Reliability analysis
- Program cost estimation



## **...What We Do**

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- **Primary U.S. Activity for Plume Related Signature Modeling and Analysis**
- **Develop and Validate Plume Codes for Distribution to DoD Community**
  - **Propulsion Performance**
  - **Exhaust Plume Characteristics and Signatures**
- **Both In-House and Contracted Work**
  - **Substantial In-House Computing and Scientific Visualization Capabilities**



## **Background**

### **Types of Plume Signatures**

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- **Propulsion Systems Produce the Following Signatures**
  - Exhaust Plumes
  - Plume/Body Interactions
- **These Signatures can Impact the Effectiveness of a Missile Defense System During Boost, Ascent, and Descent Phases**



# **Background**

## **Plumes Impact Many Missile Defense Functions**

- **Passive Signatures: Emissions in the UV-LWIR (0.1-25  $\mu\text{m}$ )**
  - Detection, Acquisition, Tracking, Typing, Cueing, Handover, Aim-point Selection, Band Pass Selection, Sensor Ranging
- **Active Signatures: Laser and Radar Attenuation and Backscatter**
  - All Weather Detection and Tracking, Typing, Communications, Aim-point Selection, and Sensor Ranging
- **Vehicle/Plume Interactions**
  - Base Heating, Engine Heat Sink, Pressure Distribution, Flow Separation, Shocks, and Contamination



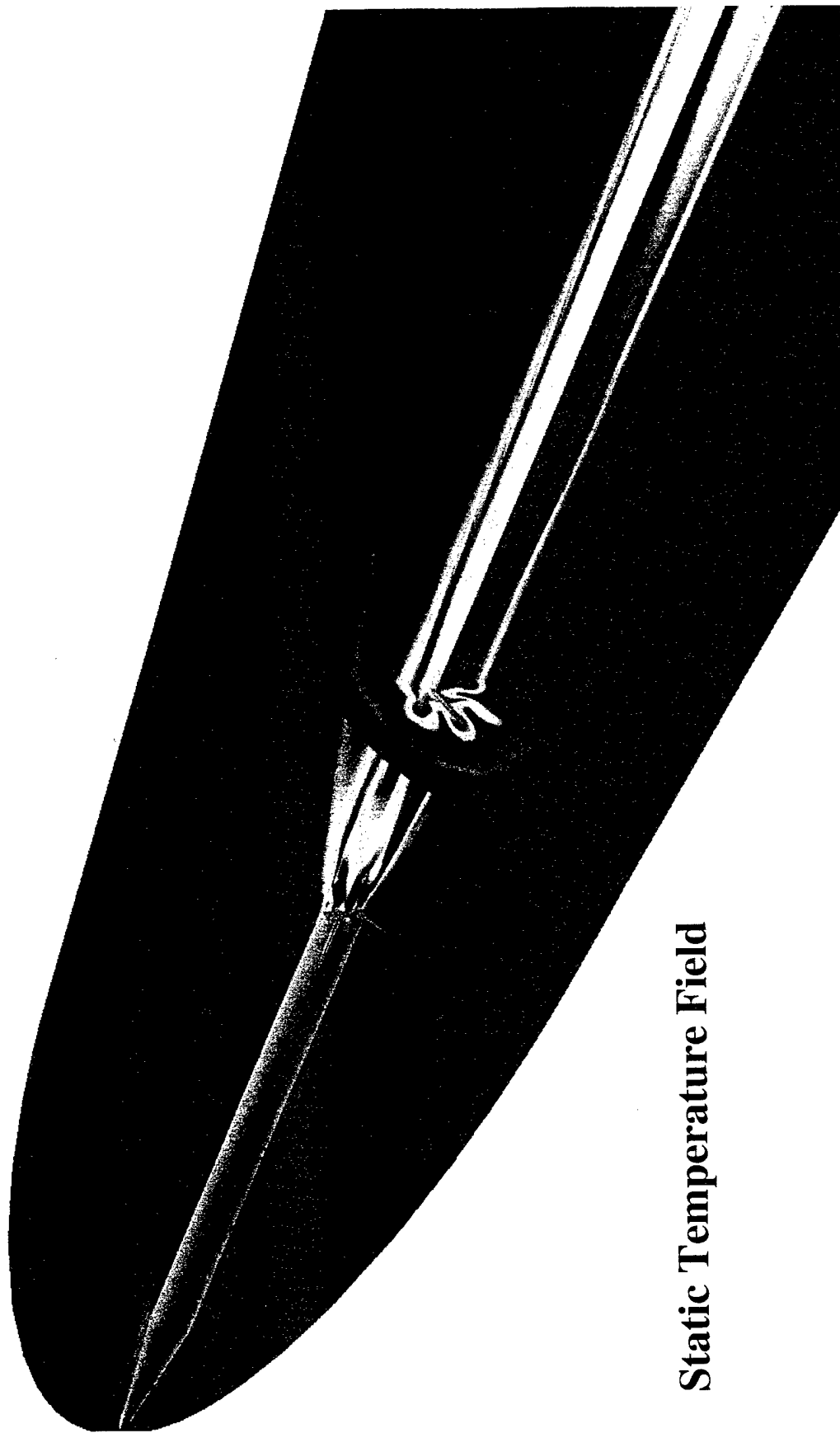


# **Plume Phenomenology Implications: A Few Examples**

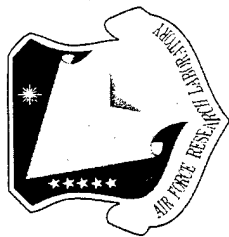
- **Plume Asymmetries**
  - 3-D Effects (Fins, Gas Generators, TVC Vanes, etc)
  - Angle-of-Attack
- **Afterburning Cessation and Shutdown**
- **Contamination**



## 3-D Simulations of Plume Flows



Static Temperature Field



## 3-D Radiation Predictions

